Note-Book for Dental Students

JAMES RYMER

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NOTE-BOOK

FOR

DENTAL STUDENTS

(DENTAL ANATOMY AND PHYSIOLOGY)

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PREFACE

As almost all branches of the medical profession have a "Note-book" written with the express object of proving useful prior to examinations, it occurred to me that a little work of this kind would be appreciated by many Dental students; accordingly, I have collected together the chief matter connected with Dental Anatomy and Physiology with the above object.

I need scarcely say that, to understand so large a subject in this condensed form, it is necessary that the general text-books should be first mastered.

I have purposely omitted a description of the jaws with their development, as they are so fully treated upon in every work on general anatomy.

My thanks are due to Mr Gaddes, as the notes taken at his lectures on Dental Anatomy are so largely reproduced, and also to Mr Charles Tomes for much information from his well-known text-book.

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10, Bentinck Street,
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NOTES ON DENTAL ANATOMY

FOR

DENTAL STUDENTS.

Teeth of Man.

Formula: Permanent, i. $\frac{2}{2}$, c. $\frac{1}{1}$, pm. $\frac{2}{2}$, m. $\frac{3}{3}$ = 32.
Deciduous, i. $\frac{2}{2}$, c. $\frac{1}{1}$, m. $\frac{2}{2}$ = 20.

For description three parts of the tooth are known, viz. (*a*) crown, (*b*) neck, (*c*) root.

(*a*) *Crown* is that portion above the gum, and is covered with enamel.

(*b*) *Neck* is that constricted portion where the enamel terminates.

(*c*) *Root* is that portion which is embedded in the bony socket and is covered with cementum.

Names to the several surfaces of the teeth.—

Mesial is the surface of the tooth nearest to the median line. *Distal,* away from the median line. *Labial* or *buccal* is the surface which is towards the lips or cheeks. *Lingual,* towards the tongue.

Incisors.—*Upper central incisors* are the largest, the median surface (that which is in contact with its fellow) is longer than the distal, so that the inner angle is more acute than the outer. At the neck there is a space, due to the narrowing of the crown near the neck. The labial surface is convex in both directions, on the surface there are both longitudinal and transverse markings due to development. The lingual surface is slightly concave in both directions, and is bounded by the cingulum, and in the median line near the gum it terminates in a projection called the "*median tubercle.*" The enamel on the lingual and labial surfaces ends in a curved line, the convexity being directed towards the gum; on the mesial and distal surfaces it ends in a V shape, the apex of the V is directed downwards, away from the gum. The root is cylindrical, tapering gradually from the neck to the apex. The form of the pulp cavity bears

a general resemblance to the shape of the tooth, but in the developing tooth the apical foramen is larger than in the fully formed tooth.

Upper Lateral Incisors are smaller than the centrals. *Distal surface* is rather concave. *Mesial* convex. The median tubercle at neck is more prominent than in the centrals, and so is the bounding ridge; there is often a fissure between the tubercle and ridge. This is a common seat for caries in the laterals, hence important to the dentist. The shape of the root and pulp cavity is similar to the centrals.

Lower centrals are smaller than the upper, and also smaller than the laterals; the distal angles are only slightly rounded off, differing from the upper. The roots are much compressed laterally with an attempt at bifurcation.

Lower laterals differ little from the centrals except they are larger in all their dimensions, and the distal angle of the crown is rounded off considerably.

Upper Canines.—*Labial surface* convex both ways; on this surface there is a well-marked longitudinal ridge, which divides the tooth

into two unequal parts, the distal half being the larger; this ridge is also seen on the lingual surface, and ends at the tubercle, the tubercle being much larger than that seen in the laterals. The cutting edge at the mesial part is sharp, at the distal it slopes off gradually. The roots are long and cylindrical, the pulp cavity bearing the same shape.

Lower Canines similar to the upper, but the median ridge is less pronounced. The root is more rounded than the lower laterals, but flatter from side to side than the upper canines.

Premolars.—*First upper bicuspid* is larger than the lower, the labial surface is greater than the lingual; there are two cusps separated by a transverse fissure on the grinding surface, joined by the "cingulum" on the mesial and distal borders; the labial cusp is homologous with the cusp of the canine, the lingual cusp being formed by the further elevation of the "median tubercle." The root of the first bicuspid is usually double.

Second upper bicuspid resembles the above, excepting the root, which is usually single; pulp sends a cornu to each cusp.

First lower bicuspid.—The inner cusp is considerably smaller than the outer, showing well the transitional stage between the canine and bicuspid; a median ridge unites the two cusps. the root is somewhat rounded, the cornu of the pulp, which corresponds to the inner cusp, is scarcely visible; otherwise it is regular.

Second lower bicuspid.—The inner cusp is here even larger than the outer, and the ridge is often thickened at the distal surface giving the appearance of three cusps; this shows the relation the molar bears to the bicuspids. The roots are similar to the above; the cornu of the pulp to the inner cusp is more developed.

Molars.—*First and second upper* are squarish in shape, edges rounded off. The grinding surface supports four cusps, the antero-internal being the largest, and is connected with the postero-external by an oblique ridge; the enamel is thickened on the mesial and distal borders. There are two fissures on the crown, the buccal and lingual surfaces are grooved by these fissures (these are favourite spots for caries). They have three roots. Anterior buccal larger than the posterior, and flattened

in the anterior and posterior direction. The palatine root is cylindrical and is directed obliquely upwards and inwards.

Third upper molar (*wisdom*) varies in shape and size, it usually has the roots fused into one ; it has only three cusps, two of which are buccal.

First lower molar on grinding surface has five cusps, fissures divide this surface into four parts ; near the distal surface of the tooth one fissure bifurcates, and in the space there is another cusp (the disto-buccal or fifth cusp). The lower molars have two roots, anterior much the larger and grooved, showing an attempt at bifurcation ; the pulp cavity takes the form of the tooth, but in the roots there are generally two canals which become confluent at the apex.

Second lower molar differs little from the above, but has only four cusps, the fifth is generally absent.

Third lower molar (*wisdom*) usually has five cusps, but varies much in size and shape, as was seen with the upper wisdom.

The Deciduous Teeth differ from the permanent, viz. (1) necks are more constricted ;

(2) roots more divergent, in order to make room for the succeeding permanent teeth; (3) they are smaller; (4) the enamel terminates in a thick edge at the necks of the teeth; (5) the first upper molar has three cusps, second upper molar has four cusps; first lower molar has four cusps, and the second lower molar has five cusps; (6) they have a perpendicular implantation.

Relation of Teeth in the Upper and Lower Jaws.—Each tooth in the upper jaw, except the wisdom, articulates with two teeth in the lower jaw.

Forms of the several teeth.—Teeth are modifications of a cone, plate, or prism, and the teeth of mammals may be regarded as modifications of the cone by additions to and suppression of parts.

Terms applied to the types and number of successional teeth.

Monophyodont.—Definition: Is the name applied to those animals which have only one set of teeth. Examples: Cetaceans, wombat, rats and mice.

Diphyodont.—Definition : Is the name given to all animals which have two sets of teeth. Examples : Most mammals, as man.

Homodont is the name given to those animals which have teeth all of one shape and form. Examples : Sperm whale and dolphin.

Heterodont, those animals which have teeth of different forms are called by the above name. Examples : Most mammals.

Heterodonts as a rule are *Diphyodont,* except rats, mice, wombat, and the two-toed sloth.

Homodonts as a rule are *Monophyodont* except nine-banded armadillo.

The Attachments of Teeth (four kinds) :— (*a*) Fibrous ; (*b*) hinge ; (*c*) anchylosis ; (*d*) sockets.

(*a*) *Fibrous.*—Examples : Sharks and rays, &c. Their teeth are embedded in the tough fibrous membrane which covers the jaws.

(*b*) *Hinge.*—Examples : The angler and hake. Connected with the larger teeth there is a dense fibrous ligament attached to the *inner side* of the base of the tooth ; the tissue around the rest of the base is more yielding, so the teeth can be bent inwards but not outwards. In the pike some of the teeth have

the "hinge action," the hinge being formed by semi-calcified trabeculæ in the axial part of the tooth, so they go back with a "click."

(*c*) *Anchylosis.*—Examples: Reptiles, eel, haddock, and bony fish generally. The bone nearest the tooth is called the "bone of attachment," it is coarse in texture and full of irregular spaces, and so differs from true bone.

(*d*) *Sockets.*—Examples: All mammalia as man, rostral teeth of saw-fish, ichthyornis, crocodiles.

Dental Tissues.—*Enamel.*—On the scales of some fish, *ganoids,* there is a substance almost similar to enamel called "*ganoin,*" it is one of the simplest forms of enamel and is almost structureless.

Enamel is the hard dense material which forms a cap over the dentine; *no* enamel is found in edentates, as sloths, armadillos, and ant-eaters, certain cetaceans as narwal, some reptiles, and many fish.

Structure. — Highly developed enamel is structureless, and in human teeth it contains only 3½ per cent. of organic matter.

Composition :

Phosph. and Fluoride of Calcium	89·82
Carb. of Calc.	4·37
Phosph. of Magnesium	1·34
Other salts	·88
Cartilage	3·39
Fat	·26

It is most simple in the teeth of the manatee, the enamel fibres are said to pursue a straight course ; in the rodents, as beaver, rats, and squirrel, the enamel prisms start almost at right angles to the dentine in alternate and superimposed layers ; in the inner two thirds they decussate and then all bend up at one angle and run parallel for the outer one third.

In the porcupine family the inner parts of the prisms are flexuous, the outer parallel. In the leporidæ or hares the prisms are slightly flexuous all throughout.

Human enamel.—The hexagonal prisms are neither perfectly straight nor parallel, the curvatures are most marked at the masticating surfaces ; the fibres alternate in planes transverse to the long axis of the crown, and so get the fine striæ on the free surface of the enamel due to the out-croppings of the alternating

fibres. "Supplemental fibres" are added externally, for there is a greater surface. On the enamel prisms there are "striæ" due to the decussation of the fibres. Other views with regard to these striæ: (*a*) "Due to intermittent calcification" (Hertz); (*b*) "they are varicosities in the individual fibres" (Kölliker). The axial portion of the enamel fibre is less calcified and so easier acted on by acids.

"*Brown striæ of Retzius*" are lines on a large scale which correspond to what was at one time the outer surface of the (developing) enamel. They run inwards and towards root.

Pigment is sometimes seen deposited on the outer surface of the prisms. Examples: Beaver and rat.

"*Tubular enamel.*"—Sometimes tubes exist in the enamel; their contents have not yet been demonstrated. It is found in marsupials, exception the wombat, in some rodents, jerboa, some insectivora, and in the lizard *Cyclodus gigas*. Tubular enamel is also found in the sargus (sheep's head fish), the tubes are empty and open on the free surface of the enamel.

Dentine.—There are four kinds of typical

dentine, viz. (1) osteo-dentine, (2) plici-dentine, (3) vaso-dentine, (4) hard unvascular dentine.

(1) *Osteo-dentine* consists of a hard calcified matrix permeated by a system of large channels, containing pulp matter; dentinal tubes may or may not be a necessary condition to osteo-dentine; when present they radiate from the several channels. There is an intimate connection between this form of dentine and bone. In osteo-dentine the course of the arteries is independent of that of the canals. Examples: Common pike, sharks, and pathologically in human teeth.

(2) *Vaso-dentine* consists of a hard, calcified matrix, permeated by a system of canals far larger than ordinary dentinal tubes, which anastomose freely with one another; they are regular and contain only capillaries (differing from osteo-dentine). When dentinal tubes are present they radiate from the axial pulp chamber. Examples: Hake, flounder, and most flat fish, manatee, tapir, extinct megatherium, and pathologically in man.

(3) *Plici-dentine,* or "*folded dentine;*" in transverse section furrows or markings can be seen due to the dipping in of the dentine;

sometimes "lacunæ" (similar to bone-corpuscles) are found between the dentinal systems. Examples: Bony pike of North America, extinct labyrinthodon, myliobates, rostral teeth of saw-fish, varanus, &c.

(4) *Hard unvascular dentine or human dentine.*—When broken there is a lustre on its surface, it is white, hard, and unvascular. Structure: It consists of an organic matrix richly impregnated with calcareous salts. The chemical composition is:

Organic matter	27·6
Fat	·40
Phosph. and Fluor. Calcium . . .	66·7
Carbonate of Calc.	3·4
Phosph. of Magn.	1·0
Other salts	·9

The matrix is permeated with parallel tubes, which, for the most part, are at right angles to the surface; these contain "dentinal fibrils." The organic matrix is a gelatinous substance of firmer consistence than that of bone, and does not so easily yield its gelatine on boiling as bone does.

Dentinal tubes.—These are larger at the pulp end than at the periphery; the size of a

dentinal tube is $\frac{1}{4500}$ to $\frac{1}{10000}$ inch, and cannot contain any blood-corpuscle, so they are unvascular. There are between two and a half to three and a half "*primary curves*" in the dentinal tubes from their beginning to their end; in the root of the tooth these curves are smaller, they run parallel to one another, and this coincidence gives rise to shadings, denominated the "*lines of Schreger;*" other lines are seen running downwards and outwards, called the "*contour lines*" (Owen) or *incremental lines* (Salter); they really indicate the developmental lamination of the tooth, and are masses of "interglobular areas," faults in calcification (*vide* Development).

"*Secondary curves*" of the dentinal tubes are far more numerous, 200 having been counted in one tenth of an inch; these curves are more common in the root of the tooth than in the crown. As the dentinal tubes pass outwards from the pulp they give off branches, these branches are more common in the root; the tubes end near the surface of the cementum, some by anastomosing with one another, some in the "interglobular areas," others by running through the "interglobular

areas," and communicating with the canaliculi of the cementum. These "interglobular areas" (which are due to imperfect calcification, viz. the non-union of the "calco-sphirites") being so commonly found in the root, it is not considered abnormal, but when met with in the crown it is such a degree of faulty development as to be looked upon as abnormal.

Contents of the tubes.—These contain a process from the odontoblast (Beale, Tomes) or of the cell beneath (Klein) (*vide* Pulp). The "*sheath of Neumann*" is simply the imperfectly calcified dentinal tube—"calco-globulin." "*Cetacean dentine*" is the name given to dentine of the cetacean animals; it contains a large number of "interglobular areas." "*Areolar dentine*" is dentine in which the interglobular areas are calcified, but their contours are still visible.

Cementum in human teeth is confined to the roots, but in many animals it also covers the crown; this is the case in recently erupted human teeth, where it is spoken of as "*Nasmyth's membrane.*" It contains no "Haversian system" or vascularity except pathologically.

Structure.—Cementum consists of a calcified

laminated basis substance, containing "*lacunæ*" and "*canaliculi;*" its surface is nodular (due to development), and this portion is denser, more resistant to dilute acids, and therefore it is not so fully calcified. The lacunæ differ from those of bone in being irregular in shape, size, and distribution; their long axes are generally placed parallel with the lamellæ; the "canaliculi" are more numerous from the periosteal side of the lacunæ, fewer run inwards towards the dentinal surface; they are irregular in shape and size. The lacunæ contain the remains of the formative "osteoblasts." The cementum at the neck of the tooth neither contains lacunæ nor lamellæ, differing from the remainder; this is due to the extreme thinness. Like bone, cementum contains "fibres of Sharpey;" these are developed from the formative periosteum, and are calcified bundles of fibrous tissue.

Nasmyth's Membrane has many names. "Huxley" described this membrane as the "membrana preformativa;" another theory, "Waldeyer" considers the "external epithelium of the enamel organ" to be the source of

Nasmyth's membrane, and that in the course of development this layer is lost. Another theory, which is probably the correct one, that it is rudimentary cementum, "Tomes," &c., and that usually containing no lacunæ or lamination is due to its extreme thinness, but between the cusps (as bicuspids) lacunæ (of the nature of encapsuled lacunæ) have been found. This is the chief reason in favour of its being rudimentary cementum. Secondly, when sections of teeth are ground down, "Nasmyth's membrane" is occasionally seen to be continuous with the cementum; thirdly, in mammalia a thick layer of cementum (identical with Nasmyth's membrane) is seen covering over the enamel of their teeth; fourthly (*vide* Development), the dental capsule which forms the cementum of the roots goes also round the enamel organ. Nasmyth's membrane is very resistant to dilute acids (which destroys enamel); when boiled in caustic potash it swells up, and when treated with nitrate of silver it is stained, showing a reticular appearance, due to the edges of the epithelial cells being stained black; fallacy, this membrane being in intimate relation with

the enamel, some think that the reticular character is due to the imprints from the hexagonal prisms. In children who have just cut their teeth, and before they are worn, the teeth have a yellow appearance; this is "Nasmyth's membrane;" it speedily wears off, leaving the white enamel.

Tooth Pulp.—In the human teeth the pulp is the remains of the formative tooth papillæ, and consists of (1) cells, (2) connective tissue, (3) vessels, and (4) nerves.

(1) The cells, "*odontoblasts,*" are large, and radiate at right angles to the surface; they entirely cover the pulp surface, and are intimately adherent to the dentine, forming a kind of false membrane, "membrana eboris." The "odontoblasts" have three sets of processes, the dentinal process (*vide* Dentine), lateral processes, which unite the cells together, and a pulp process. They are of columnar shape, and have a large nucleus. The cells beneath the odontoblasts are spherical and nucleated, and, according to "Klein," the dentinal process is derived from these cells and not from the "odontoblasts." There are also other small cells scattered through the pulp,

"connective-tissue corpuscles," or "granules of Purkinje."

(2) The *connective tissue* is finely fibrous, gelatinous, and mucoid in composition.

(3) The *blood-vessels* are very numerous, three or four to each tooth; they at first run parallel, and then break up to form a network of anastomoses.

(4) The *nerves*, three or four in number, freely communicate with one another, forming a plexus, and terminating immediately beneath the "*membrana eboris*." "Boll" has seen the nerves terminate in minute filaments between the "odontoblasts;" this has not been confirmed. No nerves have been seen to enter the dentine. The reason why dentine is sensitive is this: the dentinal process being composed of protoplasm is capable of transmitting a molecular or sensitive wave to the nerve-plexus, and thus on to the sensorium. The periosteum of the tooth sends a process or sheath to the vessels of the tooth. A short distance up the apical foramen this process of periosteum may form cementum pathologically (a cause of obscure neuralgia). A young pulp is relatively larger than an old one, and con-

tains more cell-elements and less fibrous tissue.

Periosteum is the membrane which intervenes between the alveolus and the fang of the tooth. It consists of white fibrous tissue, cells, blood-vessels, and nerves, with very little elastic tissue, and no fat. It is somewhat thicker at the neck than over the root of the tooth. The fibres of the periosteum run *downwards* and *inwards* to the root, so the more pressure brought to bear on the tooth the more tense are the fibres. Structurally there is one common periosteum for the tooth and socket, and the fibres at the cemental surface are looser than at the bone; the fibres attached to the bone are arranged into bundles, and so some parts are seen to be denser than others. In the "reticular" or "cemental fibres" cells or "osteoblasts" are seen, as also at the bone surface; corpuscles are also dotted all throughout the periosteum. The fibres of the periosteum at neck blend with the fibrous tissue of the gum, and with periosteum of the alveolar border. Periosteum is the source of "exostosis." New material is deposited on the cementum, the result of con-

tinued irritation. The blood supply of the periosteum is threefold, viz.

(*a*) From twig which goes to the pulp of tooth.

(*b*) From the blood-vessels of the bone.

(*c*) From the vessels of the gum; so that inflammation of the pulp may lead to "periostitis" by reason of the vessels so freely communicating.

Gum is distinguished by its vascularity, broad-based papillæ and extreme toughness; the epithelium of the gum on the surface is "squamous," that around the papillæ is of the columnar variety. Embedded in the fibrous tissue are small aggregations of cells, called "glands of Serres;" they are merely developmental remains. The fibrous tissue is very dense and close; it forms small elevations, "papillæ" or "chorium;" these papillæ are sometimes bifid with broad bases, and consist of trabeculæ of fibrous tissue, presenting a fan-like appearance. The fibrous tissue is intimately connected with the periosteum, hence in fracture of the jaw it is almost always "compound." There are very few nerves found in the gum; the arteries run into the

papillæ. There are numerous acinus glands scattered through the substance of the gums and hard palate.

Eruption of Teeth.

The cause of teeth being erupted is yet unknown.

Time of Eruption.—*Temporary:* 7th month, centrals; 7th to 10th, laterals; 12th to 14th, anterior molars; 14th to 20th, canines; 18th to 36th, post-molars.

Permanent: 6½th year anterior molars; 7th centrals; 8th laterals; 9th first bicuspid; 10th second bicuspid; 11th to 12th, canine; 12th to 13th second molars; 17th to 24th wisdoms.

The roots of the several teeth are completed about 2½ years after the crown commences to be erupted.

Development of Teeth.

The following is a table of approximate dates:—

In utero:

7th week.—Inflection of epithelium.

9th week.—First trace of dentine papilla.

10th week.—Processes detached from the base of the papilla to form the "sacculus," thus the different organs are formed.

15th week.—Special enamel germ forming the enamel organ.

16th week.—Process of the "sacculus" meets, cutting through the neck of the "enamel organ," forming a complete "dental sacculus."

The permanent enamel germs are given off from the necks of the corresponding 10 temporary enamel organs.

17th week.—A cap of dentine is formed on the incisors and canines; calcification of the enamel follows that of the dentine.

The dentine germ of the 1st permanent molar is here given off.

18th week, 4th month } Cap of dentine formed on 1st and 2nd temporary molars, and appearance of dental sac of 1st permanent molar.

20th week.—Dentine germs of 10 anterior permanent teeth, and closure of dental sac of the 1st permanent molar.

25th week, 6th month } Calcification of dentine of 1st permanent molar beginning in cusps.

32nd week.—Cusps of 1st permanent molar coalesce.

39th week, 9th month } Closure of dental sac of 10 anterior permanent teeth.

Birth:

1st month.—Calcification of 10 anterior permanent teeth.

3rd—7th months.—Enamel organ of 2nd permanent molar is given off.

1st year.—Dentine germ of 2nd permanent molar appears.

3rd year.—The enamel organ of 3rd molar is given off.

6th year.—The dentine germ of 3rd molar appears.

Development of the teeth in man.—At the sixth week (*in utero*) the lower jaw consists merely of "Meckel's cartilage" surrounded with embryonic tissue; at the seventh week there is a roundish depression, with thickened borders formed by the epithelial cells proliferating all around the jaw (at the future site of the alveolar margin). In transverse section the epithelial cells under this altered region have multiplied, forming a *cul-de-sac* of epithelium which is embedded in the embryonic tissue; this common inflection of epithelium gives off secondary distinct narrow inflections, which will ultimately form the *enamel organs* of the temporary teeth. The cells upon the periphery of this inflection, which have now assumed definite shapes (compared to a Florence flask, Tomes), are of columnar form, polygonal cells (stellate tissue) occupying the central part. This is called the "enamel germ;" the cells intervening between the columnar and stellate cells are unaltered and called "stratum intermedium;" the nuclei of the columnar cells which lie next to the dentine "papilla" or "germ" recede to their extremity. At the

same time the cells elongate and are called "enamel cells" or internal epithelium of the enamel organ.

The enamel organ consists from without inwards of—(*a*) external epithelium, round or elongated cells; (*b*) stratum intermedium; (*c*) stellate reticulum; (*d*) internal epithelium. The external and internal epithelium are continuous at the base of the enamel organ, and the summit of the external epithelium is still in contact with the "stratum Malpighii" through the "neck of the enamel organ."

The bulk of the "enamel organ" consists of a stellate tissue, which is surrounded by the internal and external epithelium of the enamel organ. The essential portion of the enamel organ is the "internal epithelium" or "enamel cells;" they are very regular and perfect columnar cells; they are long, containing a large oval nucleus, which occupies the extremity of the cell farthest away from the forming dentine. The enamel cells have processes which are continuous with the cells of the "stratum intermedium;" these latter are used up by the "enamel cells" in the formation of the enamel. The cells of the "stratum

intermedium" are branched cells of irregular shapes; the "stellate" cells have long communicating branches, the interspaces being filled in with albuminous material. The function of the "stellate" tissue is unknown. The "external epithelium" is composed of roundish cells, and it appears to have no function. "Waldeyer" says it forms Nasmyth's membrane. "Kölliker" and "Magitôt" say that it atrophies entirely.

The inner surface of the enamel organ is quite smooth, the outer is rough, forming papillæ; into these, vessels enter from the dental sacculus.

Dentine Germ.—Almost at the same time that the enamel germ is forming, there appears in the embryonic tissue a darkened area all round the jaw; this is the "dentine germ." From this prolongations are given off, and are called "dentine bulbs" or "dentine organs;" they grow upwards, and are embraced by the "enamel organ," which latter forms a complete cap for the "dentine organ."

Origin of the Enamel Germs of the Permanent Teeth.—The teeth which have deciduous predecessors are derived from part of their germ;

the two true molars on each side have a distinct origin, viz. from buddings from the germ of the preceding molar.

The "*dentine germ*" or "*bulb*" was seen at first to be only as a darkened area; it speedily lays down the shape of the future tooth, and becomes in contact with the enamel organ. The layers of cells next to the enamel are the source of the dentine, they are large, and form a covering over the rest of the forming dentine, known as "membrana eboris;" these cells are the "odontoblasts." They are described elsewhere.

Calcification of the teeth.—There are two modes of calcification. (1) Secretion from the end of a cell which becomes calcified. (2) Direct calcification of the cell itself; this latter takes place in teeth and bone.

Calcification of the enamel.—The enamel cells were found to be hexagonal, due to equal pressure, and calcification goes on from within outwards, and from the sides of the individual cells from without inwards; the cell protoplasm becomes transformed into a gluey-like "basis substance" commencing at the inner end of the cell; in this little granules appear,

which gradually become agglutinated and calcify. This organic "basis substance" or "formed material" which becomes incorporated with the lime-salts in *solution* (now imperfectly calcified) is called "**calco-globulin,**" and the organic calcified granules are called "**calco-spherites.**" The axial portion of the enamel-cell is the last to calcify, and can be pulled away from the calcified portion of the cell; this is called "Tomes' process." This process divides the cell roughly into two portions; each portion is called "Tomes' spicule."

The "brown striæ of Retzius" are formed by the imperfect union of the minute granules above mentioned, and are interglobular areas.

Changes which take place in the production of dentine.—In the "odontoblast cell" the axial portion, or "Tomes' fibril," does not calcify. The "sheath of Neumann" is the name given to that portion which surrounds "Tomes' fibril;" it is not perfectly calcified. The remaining portion of the cell is homogeneous, and so structureless. Calcification of dentine takes place from without inwards, and in the individual cells from without inwards; "inter-

globular areas" are also seen in dentine; sometimes these areas eventually calcify, forming "areolar dentine." When the tooth pierces the gum the pulp cavity is very large; as age advances so the pulp diminishes in size.

The **Dental Sacculus** consists of fibrous tissue, blood-vessels and cells; it surrounds the forming tooth, and from it both the cementum and, to a great extent, the periosteum are derived. The fibrous tissue forming the cementum, and the cells, "osteoblasts," are nearly all obliterated during the process of calcification, especially at the neck of the tooth. The canaliculi in the cementum are due to the non-calcification of the "formed material" in certain areas. When the outline of the osteoblasts do *not* blend with one another, their outline remains; these are called "*encapsuled lacunæ*" (*vide* Nasmyth's Membrane).

"*Osteoclasts*" are cells which are present during the shedding of the temporary teeth; they have the power of absorbing the bone and roots of teeth; they probably are transformed and altered osteoblasts, and are called also "*myeloid*," "*giant-*," or "mother-cells."

They have three or four nuclei, are found in fœtal bones, and in tumours.

Glands of Serres, when present, are seen in the fibrous tissue of the gum, and are caused by the breaking up of the neck of the "enamel organ," which leaves some of its cells scattered about; these cells are believed by some to be the origin of "supernumerary teeth."

The gubernaculum is a band of fibrous tissue which communicates with the crypt of the permanent teeth; it is supposed by some to convey vessels to the "*dental sac*" of the developing tooth.

Distribution of Teeth.

Teeth of fish.—Maxillary bones in fishes are toothless, and are movable. Exceptions: salmon and edentulous sturgeon, and hippocampus.

Fish may be grouped into—

I. *Pharyngobranchii.*—Example: Lancolet.

II. *Marsipobranchii.*—Examples: Lamprey and parasitic myxine. These are cartilaginous fish; the former has horny teeth of simple conical form, which are embedded in the con-

cave circular disc which surrounds its mouth; the latter has one curved conical horny tooth fixed to the palate, which acts as a holdfast.

III. *Teleostei* comprise the ordinary fish of our rivers and seas. These fish have a bony skeleton and so called osseous. The *common pike's* mouth is crowded with sharp-pointed teeth which are directed backwards. The wolf-fish has very formidable teeth which are anchylosed to the bone; this fish feeds upon shell-fish. The salmon at breeding season has a tubercle composed of cartilage which is developed at the front part of the lower jaw.

IV. *Ganoidii* comprise a number of extinct fish. Of existing fish the lepidostens, or bony pike of North America, is most familiar.

V. *Elasmobranchii* comprise *sharks* and *rays;* their skeletons are cartilaginous, with an ossified crest. The teeth of shark tribe are carried on cartilage of both upper and lower jaws, and are constantly dropping off, and are replaced by others under the mucous membrane. The *pristis,* or *saw-fish,* has in addition an enormous snout, like a gigantic spatula; its edges have sharp spines which are socketed, and grow from persistent pulps.

Teeth of rays (skates) are blunter and set closely, forming a continuous pavement, suitable for crushing hard substances. Examples: Myliobates; their teeth are formed *behind* and work forwards.

VI. *Dipnoi,* nearly all extinct in this order. Example: Mud fish. This fish bridges over the fish tribe with the amphibia; it lives in moist mud, and has on margin of jaws dental plates, which are anchylosed to the bone, and are notched to fit into one another.

Teeth of Amphibia.—Amphibia are those animals which can breathe like a fish with gills, and at another time have lungs and can so breathe air. Example: Toad. *Frogs* have a single row of simple conical teeth composed of an enamel cap and hard dentine in *upper jaw;* the lower jaw is edentulous and closes *inside* the upper. *Toads* are edentulous. *Newts* have teeth, which are tipped with enamel and so resemble the eel.

The *extinct Labyrinthodon* was of larger size, and had teeth in both the upper and lower jaws, and had also palatine teeth.

Teeth of reptiles, as snakes, tortoises, lizards and crocodiles.

Ophidian reptiles (snakes) divided into poisonous and non-venomous.

Non-venomous have usually two rows of teeth in the upper, and one in the lower, jaw; the teeth are anchylosed to the bone, and are used simply for catching and killing their prey and *not* for mastication. Examples: Pythons and rock snakes, &c. The *viperine colubrine snakes* are those which present transitional characters, between the harmless and the true vipers. They have fewer teeth in the outer row of the upper jaw, but the two front teeth in the outer rows are larger and grooved. This represents the poison groove in the true poisonous snakes; these teeth stand out by themselves and are conspicuous. Example: Cobra.

In the *rachiodon* (harmless snake) the teeth are exceedingly small and rudimentary, and soon drop out. The food of this animal consists of bird's eggs. In the œsophagus the eggs meet with the spinous processes of the sixth and seventh cervical vertebræ, which pierce the œsophagus, and so take the function of teeth.

Poisonous viperine snakes have only two teeth (which stand out) in the outer row; these are

the poison fangs, being fixed by anchylosis only into the movable maxillary bones. There is also considerable reduction in the number of the teeth of the inner row. The maxillary bones have an articulation with several bones of the skull, which, by means of several muscles, can fold the poison fang up to the palate.

The *poison fang* is out of all proportion to the other teeth, the canal opens just at the upper part of the tooth, and runs down near its anterior surface and terminates just *above* its apex, and so gives the point greater strength. The canal is developed by a groove, and is lined by a thin layer of dentine. It is not connected with the poison gland when the tooth is *not* erect, but when erect it stretches out the mucous membrane and so forms a duct. It can now be understood why the various snakes have such different dentitions, viz. the *harmless* snake kills its struggling prey with its numerous teeth, whilst the poisonous kills simply by injecting into its prey poison through the poison fang. Snakes and lizards have an additional jaw-bone, the "quadrate;" the increased movement which this bone gives,

enables them to swallow an enormous bolus of food at a time.

Chelonia comprise tortoises and turtles.

They have no teeth, but their jaws are covered over with a dense, horny pad.

Saurian reptiles include lizards, &c.

As a rule the teeth are confined only to the margin of the jaws, and are of simple conical forms, although of various sizes. They are anchylosed to the jaws, sometimes by the outer side of the tooth to an external parapet of bone called *Pleurodont*, and sometimes the whole base is attached to an eminence of bone called *Acrodont*.

The Hatteria (lizard) has two large teeth on the premaxillary bones, something similar to gnawing incisors of rodents. Its other teeth are quite small and *acrodont* in attachment.

In *crocodiles* the fifth teeth (canine-like) in the lower jaw, are larger and more prominent than the rest, and when the mouth is closed they are received into depressions *outside* the upper teeth in the maxillary bone.

In *alligators* there is the same arrangement, only the canine-like tooth is received *inside* the upper rows of teeth.

Teeth of Birds.—Attached closely to reptiles were many extinct birds. Those which had teeth are called odontornithes, which are subdivided into (*a*) odontoclæ, (*b*) odontornæ.

(*a*) Odontoclæ had teeth lodged in a groove, no socket, numbering 28 in upper, 66 in lower. Example: Hesperornis.

(*b*) Odontornæ had 40 upper, 40 lower, lodged in sockets. Example: Ichthyornis. The teeth are composed of a thin layer of enamel and dentine, with a large axial pulp.

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Teeth of Mammals.—*General remarks. Non-placental mammals,* as Thylacine, have $\frac{3}{3}$ premolars, $\frac{4}{4}$ molars.

Placental mammals, as horse, have $\frac{4}{4}$ premolars, $\frac{3}{3}$ molars. In examining eighty-seven specimens of extinct ungulates, forty-four were found to be the typical number of teeth, so that in man, &c., some of the teeth have been lost.

When *incisors are lost* it is generally admitted to be the outermost of the series. Exceptions: Otaria seal the first incisor is lost, in camel first and second have disappeared.

When premolars are lost the first or inner-

Stages of Tuberculism after Cope

I Haplodont

II a Protodont

II Tricuspidont

III Tuberculars

most of the series is the first to disappear. Exceptions: Bears and bats.

Loss of molars takes place by the posterior one disappearing. Exceptions: Kangaroo and hog.

Teeth of mammals are divided into three groups: (*a*) *Ornithodelphia*, or animals without vagina or ~~teats,~~ comprises one order, viz. *Monotremata*, with only two genera, the *Echidna* (or spiny ant-eater), which is edentulous, and the *Ornithorhyncus* (or duck-mole); this animal has no true teeth, ~~but~~ has on its flattened bill eight horny plates, two on each side of each jaw.

(*b*) *Didelphia*, animals with a vagina, but young are born without any placenta; comprises also only one order, viz. *Marsupialia*. These animals have true teeth, and their teeth imitate many orders of placental animals.

The typical dental formula of marsupials is: i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{3}{3}$, m. $\frac{4}{4} = 44$, and they are peculiar in having only one deciduous tooth on each side of the jaws, viz. a milk molar, which in kangaroos is displaced by the third premolar. Exception: the wombat, which has no deciduous teeth.

Marsupials have tubular enamel, except wombat, and they mimic in their dentition several of the placental mammals.

Thylacine represents the order *Carnivora*. Dental formula is: i. $\frac{4}{3}$, c. $\frac{1}{1}$, p. $\frac{3}{3}$, m. $\frac{4}{4} = 46$; the incisors are small, close-set, and sharp; the canines are strong, the premolars are conical, two-rooted teeth, both similar to the teeth found in the dog. Molars increase in size to the third, but the fourth molar is the smallest.

Dasyurus (Tasmanian devil).—Although smaller than the Thylacine, has much the same dentition.

Myrmecobius is a small animal representing the order of *Insectivora*. Formula: i. $\frac{4}{3}$, c. $\frac{1}{1}$, pm. $\frac{3}{3}$, m. $\frac{6}{6} = 54$.

Phalangers are small nocturnal animals with only a single pair of incisors in the lower jaw, otherwise the dentition is almost similar to the kangaroo rat.

Hypsiprymnus (kangaroo rat).—Small herbivorous animals, and like the wombat, representing the order of *Rodents*. Dental formula: i. $\frac{3}{1}$, c. $\frac{1}{0}$, pm. $\frac{1}{1}$, m. $\frac{4}{4} = 30$. The first two upper incisors are sharp and bend downwards: these grow from persistent pulps; the two other

upper incisors are smaller and do not have persistent pulps; the lower incisors (two) are large, similar to hare's, and meet with the six upper; the canines are small; the premolars are peculiar teeth, the crowns are very long from back to front, forming serrated blades. The molars are square, with four cusps.

Halmaturus (kangaroo).—Herbivorous animals. Dental formula: i. $\frac{3}{1}$, c. $\frac{0}{0}$, pm. $\frac{1}{1}$, m. $\frac{4}{4} = 28$. The dentition is very similar to the kangaroo rat, but it is often confusing, for this reason, the third premolar being of such long dimensions, generally displaces second premolar besides the milk molar; so in an adult jaw the formula is: i. $\frac{3}{1}$, c. $\frac{0}{0}$, pm. $\frac{0}{0}$, m. $\frac{2}{2} = 16$.

Phascolomys (or wombat) is an animal which lives on roots and burrows in the earth. Dental formula: i. $\frac{1}{1}$, c. $\frac{0}{0}$, p. $\frac{1}{1}$, m. $\frac{4}{4} = 24$. This animal *mimics a rodent.*

Incisors are large, chisel-shaped, with long roots, growing from persistent pulps; molar teeth are grooved, and also grow from persistent pulps. The wombat *differs* from other marsupials, viz. (1) it has *no* tubular enamel; (2) its molars grow from *persistent* pulps; (3) the surfaces of the incisors are covered with

cementum; (4) it has *no* temporary dentition.

(c) *Monodelphia* group are placental mammals, and all animals mentioned below come under this group.

Edentata.—Name given to those animals which have no incisor teeth, but some have been discovered having incisors which belong to this class, but in all instances the *central incisor is wanting.*

The "scaly" and "hairy" ant-eaters are quite edentulous.

Edentates as a rule are homodont; monophyodont, except "two-toed sloth." Teeth are of simple form, growing from persistent pulps, with no enamel on crowns, much of the dentine being of the nature of "*vaso-dentine.*"

Nine-banded armadillo is diphyodont, homodont (having milk teeth). It has seven simple teeth on each side of jaws; before worn they are bilobed on the surface.

In the *armadillos* the average number of teeth is thirty-two. Exception: *Priodon*, which has 100 teeth.

Sloths have eighteen teeth, which are soft, and are composed of "*vaso-dentine.*"

Sirenia comprise two genera, *Dugongs* and *Manatees*. They are fish-like in form, living in shallow water, but they are air-breathing animals.

Manatee.—The front part of the jaws does not contain any teeth, but has a dense horny pad. In very young animals there are two rudimentary incisors buried in this horny pad. The back part of the mouth contains $\frac{11}{11}$ molars. As these develop they work forwards, and the anterior ones gradually drop out. This animal is monophyodont heterodont; the dentine is "vaso-dentine;" the enamel fibres are perfectly straight (*vide* Enamel).

Dugong.—In the male there are two large incisor tusks, which project from the bent portion of the upper jaw; in the female the tusks are rudimentary. In the young dugong there are two incisor teeth, which are shed early. The dugong has five molars on each side of the jaw, which are lost in the same way as in the manatee. This animal is regarded as diphyodont.

Cetacea comprises whales, porpoises, dolphins, &c. All animals possessing teeth in this order are homodont or monophyodont;

the teeth are composed of "hard dentine" with an investment of cementum, and in some instances they are tipped with enamel. The dentine is also remarkable in containing a number of "*interglobular areas.*"

Dolphin has 200 conical, sharp-pointed teeth, which interdigitate with one another.

Porpoise has about 100 teeth, whilst the *grampus* has still fewer.

The *sperm whale* has a number of teeth in the lower jaw.

In the *narwal* all the teeth are rudimentary and disappear very early, except the upper incisors; one of these (the left) grows to an enormous length (10 feet) from a persistent pulp, having spiral grooves on its surface running from right to left. This tusk is regarded as a sexual weapon, for in female narwals they are rudimentary. The right incisor remains stunted and buried in the bone.

In *whalebone whales*, in the adult, "baleen plates" are representative teeth, but in fœtal whales there are rudimentary teeth which are ~~lost~~ absorbed soon after birth.

Ungulates.—Nearly all ungulates are her-

bivorous. The typical dental formula is: permanent, i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{3}{3} = 44$; *deciduous*, i. $\frac{3}{3}$, c. $\frac{1}{1}$, m. $\frac{4}{4} = 32$; they are divided into two classes, viz.:

(a) *Perissodactyle*, or "*uneven toed.*"
(b) *Artiodactyle*, or "*even toed.*"

Perissodactyle ungulates.—When horns are present in this order they are *not* supported on bony cores, but are merely attached to the integument; they take the place of the canines.

Rhinoceros.—Dental formula: i. $\frac{2}{2}$, c. $\frac{0}{0}$, pm. $\frac{4}{4}$, m. $\frac{3}{3} = 36$. In the adult *African* species there is a great tendency for the incisors to be lost; but they are present in the young and also *well developed* in the *Indian* rhinoceros. In the upper jaw the *outer incisor* is the *one missing*, whilst in *lower* jaw the *central* is *absent*; the first premolar has no predecessor, it is soon developed and soon lost; the molar teeth are of rather complex pattern and increase in size from before backwards.

Tapir.—The dental formula is: i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{3}$, m. $\frac{3}{3} = 42$. There is nothing peculiar about the incisors and canines save the lower canine ranges with the lower incisors. The premolars

and molars are characteristic, they support four cusps which are united by transverse ridge, leaving a deep transverse fissure between the two anterior and two posterior cusps.

Horse.—Dental formula: permanent, i. $\frac{3}{3}$, c. $\frac{1}{1}$, p. $\frac{4}{4}$, m. $\frac{3}{3} = 44$; deciduous, i. $\frac{3}{3}$, c. $\frac{1}{1}$, m. $\frac{4}{4} = 32$. The incisors have a peculiar dipping down of the enamel, "the pit" or "mark." There are two theories with regard to the formation of the "mark," one is that it is due to the dipping down or folding in of the enamel; another is that it is due to the raising up of the "cingulum." The central incisor is developed at two and a half years and is in use at the third year, so the "mark" is obliterated at about the sixth to eighth year. The second incisor is in use at the fourth year and the mark is worn out between the eighth and ninth year. The third incisor is in use at fifth year and is worn out between the tenth and eleventh years.

In the real "mark" there is a ring of enamel which stands well out. Guard against a "false mark," viz. one that has been imitated; you will see no enamel; the "marks" in the

lower incisors disappear before those in the upper.

The first premolar is rudimentary and soon lost. There is a space between the incisors and canines; the latter are more developed in the male than in the female.

The "diastema for the bit" is between the canine and molar series. The molars are of very complex pattern due to the foldings in of enamel or invagination of the cingulum, so the enamel stands out, leaving a constant rough surface well adapted for grinding purposes.

The extinct *Homalodontotherium* (resembling a horse) had *no diastema*; it had the typical number of teeth, gradually increasing in size from before backwards.

(7) *Artiodactyle ungulates* (even toed) comprise pigs, sheep, camels, oxen, &c. When horns are present they are always in pairs and supported on bony cores. They are divided into two classes: (*a*) Non-ruminants, as pigs, &c.; (*b*) Ruminants, as deer, sheep, &c.

Non-ruminants.—*Wild boar.*—Dental formula: temporary dentition, i. $\frac{3}{3}$, c. $\frac{1}{1}$, m. $\frac{4}{4} = 28$; permanent, i. $\frac{3}{3}$, c. $\frac{1}{1}$, p. $\frac{3}{3}$ m. $\frac{3}{3} = 40$. The

central upper incisors are separated at their bases; the third incisors stand apart from the first and second; the lower incisors are straight and implanted in an almost horizontal position; the canines are large and grow from persistent pulps; the upper canine first grows downwards, then outwards, then upwards; the lower canine grows outwards and upwards.

The canines in the male are larger than in the female. The molar series increase in size from before backwards and are of the "*Bunodont type*," that is to say, their grinding surfaces are covered by rounded conical cusps, in contradistinction to the "*Selenodont type*," that is, when the masticating surfaces of the molars present crescentic ridges.

The *wart hog*, has enormous stout canines, and the last molar equals in length all the other teeth of the molar series put together.

The *sus babirussa* has very long canines, the upper one turns up so acutely that it pierces the upper lip; they are devoid of enamel and grow from persistent pulps.

The *hippopotamus*.—Dental formula: i. $\frac{2}{2}$, c. $\frac{1}{1}$, p. $\frac{4}{4}$, m. $\frac{3}{3} = 40$. Some consider one of

the premolars is a deciduous tooth; it is always lost early. The upper incisors stand widely apart and are nearly vertical in direction; the lower incisors are implanted horizontally; the canines are enormous teeth, the lower being the larger. All these teeth grow from persistent pulps; the molars are of the "bunodont form," and when much worn they have a large island of dentine surrounded with a rim of enamel.

The *extinct Anoplotherium* had the typical number of teeth, which were all of uniform height; there was no diastema, and the molars were like the rhinoceros.

The *Ruminants* include sheep, oxen, and antelopes, deer (which have solid horns) and camels. The premaxillary bone in the upper jaw is devoid of teeth, but is covered over with a horny pad. Dental formula: i. $\frac{0}{3}$, c. $\frac{0}{1}$?, pm. $\frac{3}{3}$, m. $\frac{3}{3} = 32$.

Some consider that there are four incisors and no canines.

The *male hornless musk deer* has no horns, but has immense upper canines. The female has rudimentary upper canines.

The *Indian muntjac deer* has very small

horns, and has upper canines which turn outwards (as the tusks of a boar); these do not grow from persistent pulps.

Camelidæ.—This family is an exception to the rule; it has *one incisor* in the upper jaw, which *represents the outer one*, the inner two being missing; it also has upper canines; there is a slight interval between the lower incisors and canines.

There is nothing to note with regard to the molar series, they are of the "*Selenodont type*," and the buccal surfaces of the teeth are *concave* in the upper, and *convex* in the lower jaw. All the above animals have about twenty deciduous teeth.

Hyracoidea order, comprises only one family, viz. *Hyrax* (Biblical coney). This animal has molar teeth similar in pattern to the rhinoceros, otherwise its dentition bears more resemblance to the rodents. Dental formula: i. $\frac{2}{2}$, c. $\frac{0}{0}$, pm. $\frac{4}{4}$, m. $\frac{3}{3} = 36$. Central incisors are large, chisel-edged teeth growing from persistent pulps, with a thick coating of enamel on their anterior surfaces; outer incisors are small and soon lost; no canines, therefore, like rodent.

Proboscidea order, comprises elephants. There are two living species, "Indian" and "African." $i.\frac{1}{1}$

Indian elephants have two tusks (incisors) in the upper jaw; in the female they are small, and are composed of dentine; they have $\frac{6}{6}$ molars. Of these some regard three as deciduous; they are of large size, and are composed of parallel plates of enamel and dentine fused together with cementum. One tooth or parts of two are in use at the same time, and are developed from behind forwards.

Number of transverse plates.—1st tooth 4, 2nd 8, 3rd 12, 4th 12, 5th 16, and the 6th 24—27.

African elephants differ from the Indian, viz.: (1) Tusks are large in both the male and female. (2) The molar teeth have lozenge-shaped plates. (3) Number of plates considerably less. 1st molar 3, 2nd 6, 3rd and 4th 7, 5th 8, and 6th 10.

The *extinct Mastodon* had upper tusks, and some had lower incisors as well; the molars were of the "bunodont form," their cusps being connected together by transverse ridges of enamel.

The *extinct Dinotherium* had no upper

incisors or canines, but had lower incisors which turned downwards.

Order *Carnivora.* — The jaws are much shorter than in ungulates; the canines are large and pointed, and are always present, with very few exceptions; the molar teeth are few and thin, supporting sharp cusps; the glenoid cavities are *deep,* and have two projections, one in front and one behind; the condyle is transverse, and so there is no *lateral* or *antero-posterior* movement; the zygomatic arches are large, the reason being for the attachment of powerful muscles; the temporal fossæ are also large.

The incisor teeth are small; canines large. The premolars, the 1st is often absent, the 2nd is rudimentary, the 3rd is larger, the 4th in the upper jaw is a large special tooth called the "carnassial tooth;" it has a well-marked "cingulum" with sharp cusps, viz. one on the palatine root and two or three on the outer surface. This tooth articulates with the 1st *lower molar,* which is also a special tooth called "*sectorial tooth;*" it consists of a thin, sharp crown supporting two sharp cusps.

Carnivora are divided into aquatic and terrestrial. The latter are subdivided into :

(*a*) Cynoidea, dog-like : as dog, fox, wolf.

(*b*) Œluroidea, cat-like : hyænas, cats, lions, tigers.

(*c*) Arctoidea, bear-like : bear, racoon, weasel.

Cynoidea (dog).—Dental formula : i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{2}{3} = 42$. The upper incisors have a trilobed shape, the canines are large, and have an anterior and posterior ridge ; the other teeth partake of the typical characters above described.

Œluroidea—(Civet cats).—Teeth are all sharper than in dog tribe. Dental formula : i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{2}{2} = 40$.

Hyæna.—The jaw is short and stout, the canines are set far apart, and the molar series is reduced in number. Dental formula : i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{3}$, m. $\frac{1}{1} = 34$. The premolars are stout, pointed teeth, with a well-pronounced basal ridge, which protects the gums when the animal is crushing up bones. All the teeth in the hyæna are stout and strong, suitable for its diet (bones, &c.).

Felidæ (lion, tiger, cat).—Molar series still

more reduced. Dental formula: i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{3}{2}$, m. $\frac{1}{1}$ = 30. The incisors are short, the canines very large, widely apart and sharply pointed, with well-pronounced ridges on their surfaces. The ~~fourth~~ upper premolar is of typical, carnassial character. The solitary upper molar is rudimentary.

Arctoidea (bears, &c.). Some members of this group, as stoats and martens, are very carnivorous; others are mainly herbivorous.

Bears, being mixed feeders, the teeth are modified. Dental formula: i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{2}{3}$ = 42. The incisors in the upper jaw present a notch across the crown (so common in carnivora); the premolars are somewhat blunt teeth, the second and third being often rudimentary, whilst the first and fourth are retained. The molars are oblong teeth, raised into blunt tubercular cusps.

Weasels.—Dental formula: i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{1}{2}$ = 38.

Racoons.—Dental formula: i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{2}{2}$ = 40.

Aquatic Carnivora.—The walrus is a vegetable feeder; it has *no* lower canines, but the

upper are of enormous dimensions; they are used as a means of anchorage.

In *seals* the molars are called "*phocal teeth;*" their cusps are sharp and recurve backwards; around the neck, there is a well-marked cingulum, and by raising up of this, additional cusps are formed. The incisors are canineiform in shape.

Order *Rodentia.*—These animals are all vegetable feeders; there is a diastema between the incisor and molar series, and in some cases between the molar and premolar teeth. They have long scalpriform incisors, which grow from persistent pulps, two in each jaw, except hares and rabbits, which have two rudimentary incisors in the upper jaw placed behind the large ones. These scalpriform incisors have a cutting edge, and there is no enamel on their posterior surfaces. The molar teeth are not very numerous, viz. mouse family $\frac{3}{3}$, porcupine $\frac{1}{4}$, hares and rabbits $\frac{6}{5}$.

In hares and rabbits the molars have persistent pulps, but rats, mice, beavers, have roots. In the beaver the front aspect of the incisors is stained yellow, due to deposit of pigment in the substance of the enamel.

The capybara is the largest rodent. The incisors and molars growing from persistent pulps; these latter are of large size, and are composed of series of plates of dentine and enamel fused together with cementum. In rodents the condyles and glenoid cavities are characteristic, viz. much elongated in an antero-posterior direction, giving a wide range for gnawing purposes; the opposite to that seen in the order Carnivora.

Order *Chiroptera* or bats, divided into (*a*) Frugivorous, (*b*) Insectivorous.

Frugivorous Bats. Example: Pteropus (flying fox bat). Dental formula: i. $\frac{2}{2}$, c. $\frac{1}{1}$, pm. $\frac{2}{3}$, m. $\frac{3}{3} = 34$. The incisors are small, the canines are divided into parts by two ridges, the outer one being larger; the molars are large,

Insectivorous Bats. Example: Blood-sucking vampire. Dental formula: i. $\frac{1}{2}$, c $\frac{1}{1}$, pm. $\frac{2}{3}$, m $\frac{3}{3}$ = 32. The incisors are long and sharp, to make the puncture for sucking up blood; there are six deciduous incisors, which are replaced by only two permanent ones.

The *common bat*.—Dental formula: i. $\frac{2}{3}$, c. $\frac{1}{1}$, pm. $\frac{3}{3}$, m. $\frac{3}{3} = 38$. Milk dentition is quite

rudimentary, i. $\frac{2}{2}$, c. $\frac{1}{1}$, m. $\frac{2}{2} = 20$. In this order the crowns of the premolars are of the typical insectivorous pattern, viz. a W-shape is produced by the cusps and ridges of enamel.

Order *Insectivora* includes hedgehogs, shrews, moles, and the galeopithecus or flying lemur.

Hedgehog.—Formula: i. $\frac{3}{2}$, c. $\frac{0}{0}$, pm. $\frac{4}{3}$, m. $\frac{3}{3}$. = 36. In the upper jaw there is an interval between the central incisors, which are larger than the next two. The third incisors are very small and resemble premolars, they have two roots, and are regarded by some as canines; the fourth upper premolar is a large square tooth and has four cusps.

Moles have typical mammalian dentition, viz. forty-four, the lower canine has two roots and shuts behind the upper, and so is an exception to the general rule; it is called by some caniniform premolar; the upper canine has also two roots, the anterior one being in the premaxillary bone; the molar teeth have the typical W-shape pattern, and a well-marked cingulum.

Flying lemur is an animal connecting the *Insectivora* with the *Quadrumana*. Dental

formula: i. $\frac{2}{3}$, c. $\frac{1}{1}$, pm. $\frac{2}{2}$, m. $\frac{3}{3}$. = 34. The second upper incisor, implanted by two roots in the maxillary bone; the crowns of the first and second lower incisors are comb-like, have eight to ten processes, which are covered with enamel. The molar teeth have pointed cusps and have the typical W pattern. The milk teeth are represented by i. $\frac{2}{3}$, c. $\frac{1}{1}$, m. $\frac{2}{2}$. = 22, the lower incisors have the same peculiar character as was seen in the permanent set.

Order *Primates* or *Quadrumana*, divided into: Lemuridæ, lemurs; Simiadæ, monkeys; Anthropidæ, man.

Lemuridæ.—Lemurs. Formula: i. $\frac{2}{2}$, c. $\frac{1}{1}$, pm. $\frac{3}{3}$, m. $\frac{3}{3}$ = 36. The upper incisors are small, with a diastema between them; the lower incisors are narrow, long, procumbent teeth. The canineiform tooth is regarded as a premolar; the premolars are compressed from side to side, and are very sharp; the upper molars have the oblique ridge, as in man.

Aye-Aye.—Cheiromys Formula: i. $\frac{1}{1}$, c. $\frac{0}{0}$, pm. $\frac{1}{0}$, m. $\frac{3}{3}$ = 18. Is peculiar in having large curved incisors, growing from persistent pulps; but they have a complete investment of enamel and so differ from rodents; the milk dentition

also differs from that of rodent. Formula: i. $\frac{2}{2}$, c. $\frac{1}{0}$, m. $\frac{3}{2} = 20$.

Simiadæ, divided into: *(a) Platyrrhine* or "wide-nosed" or "New World monkeys;" *(b) Catarrhine* or Old World monkeys.

Platyrrhine or New World monkeys are only found in America, and differ from the Old World in the number of premolars. Dental formula: i. $\frac{2}{2}$, c. $\frac{1}{1}$, pm. $\frac{3}{3}$, m. $\frac{3}{3} = 36$.

Marmoset differs from other New World monkeys in having only thirty-two teeth; it has only two molars, the molar teeth often have the oblique ridge as in man.

Catarrhine or Old World monkeys. Dental formula as man: i. $\frac{2}{2}$, c. $\frac{1}{1}$, pm. $\frac{2}{2}$, m. $\frac{3}{3} = 32$.

Example: *macaque monkey*. The upper and lower incisors are implanted obliquely forwards; the laterals are considerably smaller than the centrals; the upper canines are very large and out of all proportion to the other teeth; it is regarded as a sexual weapon only. There is a diastema between the incisors and canines in the upper jaw. The upper premolars and molars have three distinct roots, and the latter have four cusps but no oblique ridge; the lower canines are smaller than the upper.

The first lower premolar is a peculiar tooth, having two roots; the anterior root is implanted forwards, so the antero-posterior extent of the tooth is increased. The crown of the tooth is bevelled off, so the *apex* of the tooth is over the posterior root; the bevelled portion of the crown articulates with the large upper canine; the third true molar is quinquicuspid.

Anthropoid apes, as gibbons, chimpanzee, orang, and gorilla.

The gibbons are the lowest and the gorilla the highest form. Although the *gorilla* resembles man in form, its dentition does not. The jaws are very square, with a large interval between the upper canines and incisors; there is no diastema in the lower jaw, the first lower premolar is like a canine, and the third molar is the largest, differing from man. In the male the canines come down after the third molar is cut, and is used as a sexual weapon. Both the milk and permanent dentitions are the same as man.

Orang teeth much like man. The centrals are larger, the laterals more canineiform, the canines stronger, and more than half as long

again as any other tooth, ~~smaller in the female.~~ The first premolar is canineiform, its outer cusp larger, and inner one very small, with a ridge uniting them together; the second premolar has three roots.

The lower incisors are large and stout teeth. The first premolar has hardly any sign of an inner cusp; the second premolar has a large inner cusp; the lower molars are similar to man, only the surfaces of the crowns have a fine wrinkled pattern.

Anthropidæ.—The teeth of man have been elsewhere described.

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cene <u>Pleodon</u> – ungulate; 44 t. canines
– markedly devel: or rather 4th teeth
in lower jaw caniniform, so that
the <u>functional</u> canine closes behind
the upper canine –

mbiyfoda) long recurved tusks in upper. Processes from diastema of lower jaw wh. guarded tusks. six incisors directed forwd. also two canines below "maxillary horn cores" sockets for canines

Protoceras – no upper incisors but had canines ♂ pairing lower incisors + canines as in ruminants – molars selenodont + bracliydont. ♀ canines ♂ 10 bony tuberances but prob. no horns. female had none

Toxodon $i.\frac{2}{2}\ c.\frac{0}{0}\ p.\frac{4}{3}\ m.\frac{3}{3}$ Cf. Tapir
lower incisors like Rodents but had Dn. on 2 sides of p
Molars had curved sockets convex outwds + apices
persist. growth roots almost met in palate mid line
Partial investment of Dn.
canines in lower jaw – only sockets above

Dillodon (Dilotherium) Skull form like bear but structure resembles ungulates. Each jaw pair Rodent form incisors. laterals have not persist pulps – in some molars rooted in others persistent pu

---

Seal dentit? reflexes to homodont + are monophyod as regards functional teeth tho' in Otaria milk teeth last for few weeks (fur seal) as a rule shed very ea after birth.
Canines marked : m. + pm little diff + simple ; erou + attrition marked. pm. 1 has no milk tooth.
Otaria $i.\frac{3}{2}\ c.\frac{1}{1}\ p.\frac{4}{4}\ m.\frac{1}{1}$ Phoca $i.\frac{3}{3}\ c.\frac{1}{1}\ p.\frac{4}{4}\ m.\frac{1}{1}$
pm + m series all except p1 have 1 principal cu + one in front + one behind it.
Seals retain 2nd dentit? cf Cetacea wh. retain 1
Walrus canines grow p. persist. pulp. dentine a has thin external layer of cement.
♀ tusks as long as but more slender than
$i.\frac{1}{0}\ c.\frac{1}{1}\ p.\frac{3}{3}$ worn to gum
in the young $i.\frac{3}{3}\ c.\frac{1}{1}\ pm.\frac{1}{1}$ + $m.\frac{5}{4}$
these may persist thro' life but often don't (usually)